Brazilian diagnostic tests: essential health supplies for COVID-19 syndromic surveillance

Testes diagnósticos nacionais: insumos essenciais para a vigilância sindrômica da Covid-19

Fabrício Vieira Cavalcante[1], Aimê Oliveira[1], Sidclei Queiroga de Araujo[1], Christina Pacheco[2], Ruth da Conceição Costa e Silva Sacco[1]

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ABSTRACT There is much evidence suggesting that mitigating the COVID-19 pandemic requires syndromic surveillance and isolation of suspected/confirmed cases. The availability of diagnostic tests in the Brazilian Unified Health System (SUS) is essential, which could be facilitated by national sovereignty in development and production, considering the high demand/lack of supply in the international market. This study identified the stages of translational research into diagnostic tests for COVID-19 in Brazil, verifying their geographic distribution, among other indicators. A cross-sectional, exploratory study based on a public database with 789 Research, Development, and Innovation (RD&I) projects regarding COVID-19, complemented by other searches, including the researchers' curricula (CVLattes). There were 89 diagnostic test projects in the database. In 45 cases, it was possible to obtain additional information to classify them according to the translational research stages. Fifteen innovations that reached the T3 stage were identified, with their products incorporated into clinical protocols in healthcare, even considering the deep budget restrictions in RD&I. Brazil has the potential to develop and implement technological products in the field of diagnostic tests for SARS-CoV-2. Public health RD&I policies need to be prioritized to expand national and international cooperation to promote effective national autonomy in syndromic surveillance and population health.

KEYWORDS Translational medical research. COVID-19 testing. Public health systems research.

RESUMO *Existe ampla evidência que a contenção da pandemia de Covid-19 requer vigilância sindrômica e isolamento de casos suspeitos/confirmados. É essencial a disponibilidade de testes diagnósticos no Sistema Único de Saúde, que poderia ser facilitada pela soberania nacional no desenvolvimento e produção, considerando-se a alta demanda/escassez no mercado internacional. Este estudo identificou as etapas da pesquisa translacional de testes diagnósticos para Covid-19 no Brasil, verificando sua distribuição geográfica, entre outros indicadores. Estudo transversal, exploratório, partindo de banco público com 789 projetos de Pesquisa, Desenvolvimento e Inovação (PD&I) em Covid-19, complementado com outras buscas, inclusive no CVLattes dos pesquisadores. No banco, havia 89 projetos de testes diagnósticos. Em 45 casos, foi possível obter informações complementares para classificá-los conforme as etapas da pesquisa translacional. Identificaram-se 15 inovações que atingiram o estágio T3, ou seja, tiveram seus produtos incorporados em protocolos clínicos na atenção à saúde, mesmo considerando-se as profundas restrições orçamentárias em PD&I. O Brasil possui potencial de desenvolvimento e implementação de produtos tecnológicos na área de testes de diagnóstico para Sars-CoV-2. Políticas públicas de PD&I em saúde necessitam ser priorizadas para ampliação de cooperações nacionais e internacionais, a fim de promover efetiva autonomia nacional na vigilância sindrômica e à saúde da população.*

PALAVRAS-CHAVE *Pesquisa médica translacional. Teste para Covid-19. Pesquisa em sistemas de saúde pública.*

[1] Universidade de Brasília (UnB) – Brasília (DF), Brasil.
fabricioocavalcante@gmail.com

[2] Universidade Estadual do Rio Grande do Norte (UERN) – Natal (RN), Brasil.

Introduction

Worldwide, until October 2021, there were 240 million confirmed cases and almost another 5 million deaths from Covid-19[1]. In Brazil, during the same period, there were approximately 21 million confirmed cases and more than 600,000 deaths[2]. As a result, research institutions from different countries began to seek technologies and innovations that could respond effectively to the pandemic, such as immunobiologicals, diagnostic tests and other non-pharmacological interventions[3].

Among the measures adopted to control the disease is population testing, aiming at early diagnosis. Associated with health surveillance, testing allows systematic analysis and data interpretation, thus helping to plan and intervene adequately[4,5]. In this sense, syndromic surveillance, based on the diagnosis, tracking and monitoring of cases, having testing as a starting point, has been used to reduce decision-making time and prevent new infections[6-8].

Safe and effective mitigation of the health, economic and social consequences of the pandemic is something that requires technological development[3]. Educational institutions, by establishing partnerships with the productive sector and the government, enhance the search for applicable solutions, transforming knowledge into beneficial products for the population[9]. Increasing the responsiveness of these players in the development of research and in the clinical application of their results is paramount for the timely mitigation of the negative effects of the pandemic. Thus, Translational Research (TR) emerges as a mediator, enabling the application of knowledge to promote and recover human health, and connects discovery, development, regulation and implementation of technology[10]. In recent years, TR's approach to knowledge translation and application in society has been the target of both the academia and the decision makers[11].

In Brazil, there is a discussion on how the alignment of this model with reality should be a catalyst for the development of endogenous technologies capable of solving health problems[12]. During the pandemic there was a visible acceleration of research production[13]. Protocols and detection methods for SARS-CoV-2 were quickly updated to promote accurate and timely diagnosis, favoring syndromic surveillance based on the screening and monitoring of cases[14,15].

Considering the relevance of diagnostic tests for syndromic surveillance, this study aimed to identify the TR stages of diagnostic test projects planned in Brazil to mitigate the COVID-19 pandemic, verifying their geographic distribution and their correlation with the number of researchers in the locality, the Municipal Human Development Index (HDI-M), the Gross Domestic Product (GDP) and the COVID-19 Specific Mortality Rate (COVID-19 SPR).

Material and methods

This is a cross-sectional, exploratory study, based on a database with a sample of 789 Health Research, Development and Innovation (RD&I) projects from 114 public universities and two Brazilian research centers (Oswaldo Cruz Foundation – Fiocruz – and Butantan Institute). Information related to these projects was obtained from the websites of these educational institutions and research centers from May 10 to 15, 2020[16].

After identifying the RD&I projects for diagnostic tests for COVID-19, TR stages were identified, as follows: 1) Recognition of the names of those responsible for the projects through a search on the websites of Brazilian universities and public notices to promote research in Brazil; 2) Consultation of the researchers' curriculum on the Lattes Platform[17] to verify any mentioning of the research and its developments; 3) Consultation in free Internet search tools to verify records such as scientific articles published by the researcher; and 4) Classification of RD&I projects according to their TR stages[18,19] and their respective themes, based on the description and objectives of the project.

TR takes place in a continuum of steps ranging from the research itself to the application of its findings to clinical practice in communities and in the public health environment[18]. These steps involve five translational movements[19]: T0 – the discovery and its scientific documentation; T1 – pre-clinical tests to evaluate safety and efficacy and clinical applicability; T2 – clinical tests to evaluate safety and efficacy through observational and experimental studies in order to develop evidence-based guidelines and protocols; T3 – evaluation of the implementation and dissemination of these guides to clinical practice; and T4 – translation to the community, with an evaluation of the impact on public health.

Data consolidation was performed by making use of the Excel® Program (Microsoft Office, 2016).

The geographic distribution of RD&I projects according to their Federation Units (FU) and municipalities was verified, and maps were prepared using QGIS (version 3.20.2, Odense), a free and open source Geographic Information System.

The location of the research center responsible for executing the RD&I project was correlated with the number of researchers, the HDI-M, the GDP and the COVID-19 SMR by using Pearson's Correlation Coefficient found in the Statistical Package for the Social Sciences (SPSS, version 24).

Data on the HDI-M 2018 were obtained from the Atlas of Human Development in Brazil[20], and GDP data were taken from the System of Regional Accounts[21]. The Covid-19 SMR and the absolute numbers on deaths were taken from the COVID Panel[2].

The quality of the educational institutions involved in the research was identified by the Folha University Ranking 2019 (RUF 2019)[22]. The dimensioning of the number of researchers was based on the Census of Researchers from the Directory of Research Groups in Brazil[17].

The study used secondary data that are publicly available, without the need for any ethical approval.

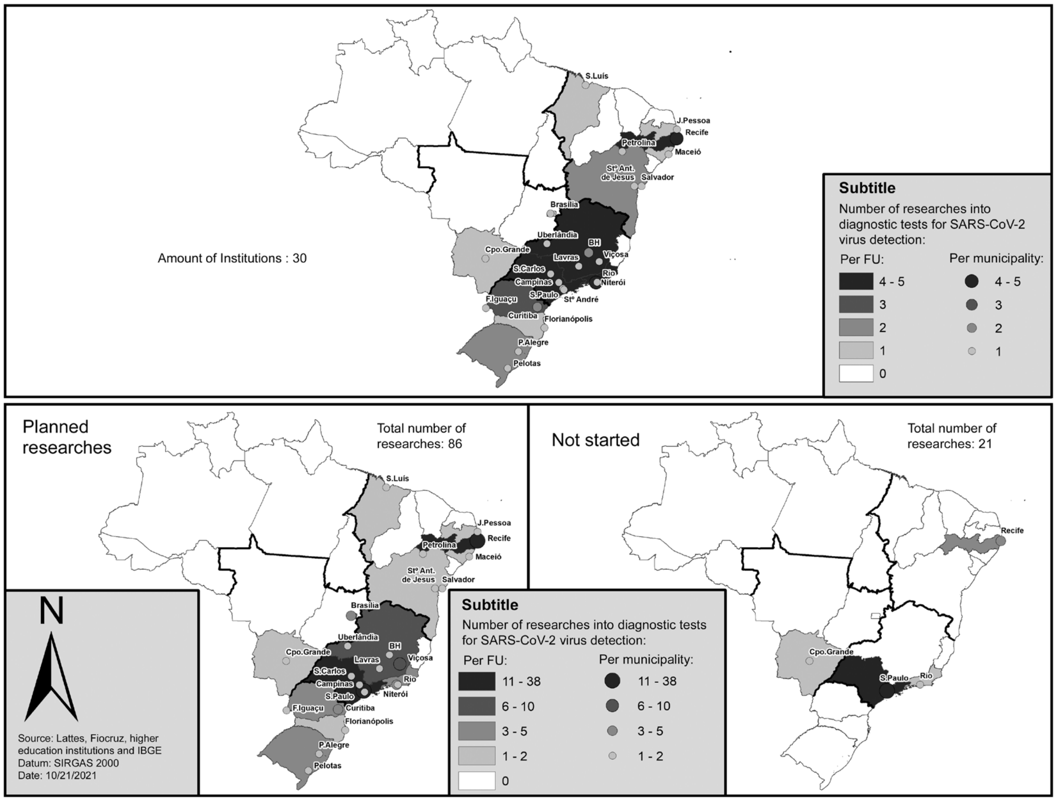
Results

TR stages were assigned for the RD&I projects on diagnostic tests aiming at the syndromic surveillance planned by Brazilian researchers to mitigate COVID-19 cases, verifying their geographic distribution and correlating them to variables such as number of researchers, HDI-M, the GDP and COVID-19 SMR.

In the database, 89 RD&I projects from 30 public institutions were related to diagnostic tests for the detection of SARS-CoV-2, the institutions being 25 universities and 5 research centers. Amongst these projects, 3.4% (n=3) were excluded due to duplicity and 22.5% (n=20) due to the impossibility of identifying the researcher in charge and his/her stage in the TR.

There was a greater concentration of research in the Southeast region, above all in the municipalities of Rio de Janeiro and Belo Horizonte – the exception to this being Recife, which is located in the Northeast region. No research was identified in the North region; and, as for the Center-West, there were studies only in Campo Grande and Brasília. *Figure 1* shows the geographic distribution of these institutions.

Figure 1. Geographical distribution of institutions with research into diagnostic tests for the detection of the SARS-CoV-2 virus by Federation Units (UF) and municipalities. Brazil, 2021



Source: Own elaboration.

Of the 86 planned surveys, the state of São Paulo had the highest number (n=38), followed by Pernambuco (n=14), Minas Gerais (n=10), Rio de Janeiro (n=5), Paraná (n=5), Federal District (n=4), Rio Grande do Sul (n=3) and Bahia (n=2). States counting only 1 survey were: Alagoas, Maranhão, Mato Grosso do Sul, Paraíba and Santa Catarina. The educational institutions with the highest number of research projects on diagnostic tests for the detection of the SARS-CoV-2 virus were also concentrated in the Southeast region, as can be seen in *table 1*, which shows their distribution by institutions according to the FUR22.

Table 1. Distribution of research on diagnostic tests for the detection of the SARS-CoV-2 virus by classification of institutions according to the Folha University Ranking (FUR), Brazil, 2021

Classification on the FUR	Number of institutions with research on diagnostic tests for the detection of the SARS-CoV-2 virus	Number of researches for diagnostic tests for the detection of the SARS-CoV-2 virus	
		(n)	(%)
The 10 best institutions	8[a]	57	66.3%
Institutions ranked between 11th and 50th	10[b]	16	18.6%
Institutions ranked between 51th and 197th	7[c]	8	9.3%
Unranked	5[d]	5	5.8%
Grand total	30	86	100%

Source: Folha University Ranking (FUR)**22**.

[a] USP (1st), Unicamp (2nd), UFRJ (3rd), UFMG (4th), UFSC (7th), UFPR (8th), UnB (9th) e UFPE (10th).

[b] UFSCar (12th), UFV (15th), UFF (17º), UFU (25º), UFLA (28º), UFPB (31st), UFPel (32º), UFABC (38th), UFMS (41st) and Ufal (45th).

[c] UFCSPA (61st), Unirio (65th), UPE (71st), Univasf (106th), UFRB (127th), Unila (125th) and Uema (157th).

[d] Fiocruz/BA, Fiocruz/MG, Fiocruz/PE, Fiocruz/PR and Fiocruz/RJ.

Of the 30 institutions, 8 are among the best in the country (according to the FUR) and concentrate more than half of the research (66.3%). The next 10 institutions, which are ranked between the 11th and THE 50th position of the FUR, were responsible for 18.6% of the surveys. Note that the 5 institutions outside the FUR, representing 5.8% of the surveys, are all Fiocruz units (*table 1*).

In order to identify the TR stages of the RD&I projects available in the database used, the ones that had not yet started were disregarded and this represented 31.8% (n=21) of them, whereas 68.2 % of projects were classified (n=45). *Table 2* shows the projects with their respective themes and classification in the TR stages.

Table 2. Classification of Research, Development and Innovation (RD&I) projects in health, in the area of diagnostic tests planned by Brazilian scientists for the detection of COVID-19, regarding the stages of translational research and their respective research topics

Translational research stage	Identified projects		Themes of RD&I projects in health, in the area of diagnostic tests for the detection of COVID-19
	(n)	(%)	
T0	20	44.5	Data science and development of diagnostic machines; strengthening of laboratory infrastructure; development of diagnostic kits; molecular techniques.
T1	5	11.1	Development of biomarkers for COVID-19; serological tests and construction of a mathematical model to estimate the diagnosis.
T2	5	11.1	Artificial intelligence in diagnostic imaging; evaluation of diagnostic tests and investigation of loss of sense of smell caused by COVID-19.
T3	15	33.3	Development of new tests; diagnostic platform formulation; use of imaging equipment; test validation for detection; artificial intelligence; development of laboratory infrastructure; development of diagnostic methods.
T4	0	0.0	-
Total	45	100	-

Source: Own elaboration.

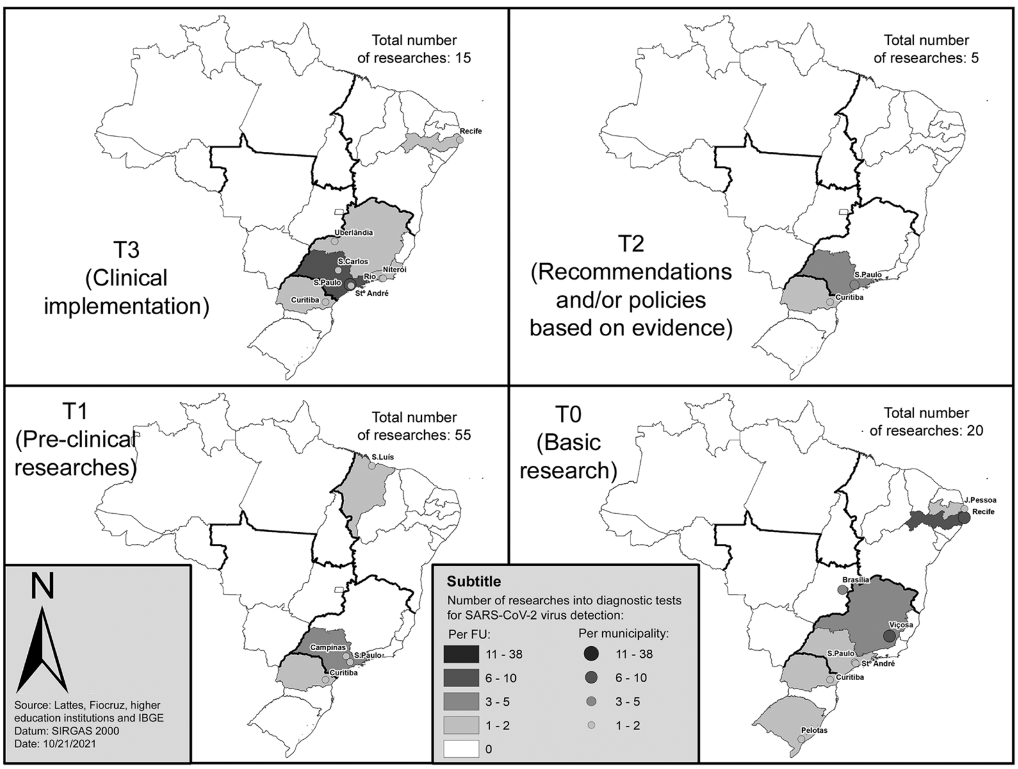
It was found that most researches 44.5% (n=20) are in the T0 stage, that of basic research. Secondly, the T3 research stage was reached by 33.3% (n=15) of projects.

The themes of the 15 translated projects (stage T3) fall into the following: artificial intelligence, new strategies for diagnosing COVID-19, use of imaging equipment, and development of methods for more timely diagnosis of SARS-CoV-2.

In this study, no research was found at stage T4, when its impact on the health of the population is evaluated in communities.

As for the distribution of research on diagnostic tests for the detection of the SARS-CoV-2 virus in Brazil, according to their TR stages, the following was observed: T0 (n=20); T1 (n=05); T2 (n=05); T3 (n=15); and T4 (n=0). Most of the research was classified as basic (T0) and had its distribution among the states of Pernambuco, Minas Gerais, Paraíba, São Paulo, Paraná and Rio Grande do Sul, besides the Federal District. Paraná and São Paulo stand out for having at least one survey in each of the stages. The Southeast region displayed the highest number of T3 surveys (*figure 2*).

Figure 2. Geographical distribution of research on diagnostic tests for the detection of the SARS-CoV-2 virus, with the respective stages they are in Brazil, 2021



Source: Own elaboration.

In this study, based on Pearson's coefficient, the correlation between the distribution of surveys of diagnostic tests for the detection of SARS-CoV-2 and other variables and indicators was also verified (*table 3*).

Table 3. Correlation matrix (Pearson's correlation ratio) between the distribution of surveys of diagnostic tests for the detection of SARS-CoV-2 and deaths by COVID-19, Mortality rate by COVID-19 (COVID-19 SMR), researchers, Gross Domestic Product (GDP) and Municipal Human Development Index (HDI-M) by Federative Unit. Brazil, 2016, 2017, 2018 and 2021

	No of researches on diagnostic tests for SARS-CoV-2	No of institutions with research into diagnostic tests for SARS-CoV-2	Number of deaths from COVID-19	COVID-19 SMR (per 100 mil inhab.)	No of researchers	No of researchers with a PhD	GDP	GDP per capita	IDH-M
No of researches on diagnostic tests for SARS-CoV-2	1	.694**	.894**	.126	.843**	.861**	.921**	.316	.434*
No of institutions with research into diagnostic tests for SARS-CoV-2		1	.710**	.094	.798**	.787**	.664**	.288	.424*
Number of deaths from COVID-19			1	.283	.968**	.975**	.987**	.362	.529**
COVID-19 SMR (per 100 mil inhab.)				1	.275	.290	.276	.658**	.705**
No of researchers					1	.998**	.953**	.422*	.585**
No of researchers with a PhD						1	.964**	.427*	.589**
GDP							1	.421*	.559**
GDP per capita								1	.891**
IDH-M									1

Source: own elaboration.

**Correlation is significant at the 1% (two-tailed) level; *Correlation is significant at the 5% (two-tailed) level.

The correlation between the number of surveys on diagnostic tests was very strong with GDP (0.921) and also strong with the number of deaths from COVID-19 (0.894), the number of researchers (0.843) and the number of researchers with a PhD (0.861).

The HDI-M, on the other hand, showed a moderate correlation, both with the number of surveys of diagnostic tests (0.424) and with the number of institutions that were developing surveys for these tests (0.434). In other words, locations with the lowest HDI-M were the ones that least developed research of this nature, which has already been shown in *figure 1*, in which, in the North region, none of them were identified.

Discussion

The study did not find any state in the North region with researches for the acquisition of diagnostic tests for SARS-CoV-2 (*figure 1*). This finding differs from the hypothesis that the locations with the highest incidence of COVID-19 were the ones that invested the most in these researches, since, according to the Coronavirus Panel of the Ministry of Health[2], on October 24 2021, the North region was identified as having the third highest incidence (10,092.3/100 thousand inhabitants), preceded by the South (14,066.5/100 thousand inhabitants) and by the Central West (14,285.8/100 thousand inhabitants) regions. On the other hand, São Paulo was the state that had the highest amount of uninitiated research (n=16), followed by Pernambuco (n=3), Rio de Janeiro and Mato Grosso do Sul (n=1).

Those results agree with the study carried out by the University Reflection Forum of the State University of Campinas (Unicamp)[23], which showed that investment in science provides decentralization of graduate studies, especially in the state of São Paulo, due to constant and meritocratic funding of research by the São Paulo Research Support Foundation.

Brazil has limited decentralization in this area, and the Southeast remains the center of transformations in the productive structure and this had its peak in the late 1960s and early 1970s[24]. It was only in the mid-1990s that, as a result of globalization (and, along with it, subordination to multinational companies), a movement of industrial deconcentration and innovation began[25].

Despite this concentration, there is the positive work of international cooperations, which is a characteristic of innovation, especially through the articulation of industrial and innovation policies with other public policies that has been carried out by historical research and teaching institutions such as Fiocruz, which is federal and has its headquarters in Rio de Janeiro, and the Butantan Institute, state institution located in São Paulo, which base their work on the connection between scientific-technological activities and the relevant socioeconomic and public health concerns[24].

The surveys identified here focus on the richest states in Brazil. Pinto Junior, Zanneti and Albuquerque[25], in a cross-sectional study on information coming from research groups, showed that the state of São Paulo concentrated 29.1% of doctors, as well as 29.1% of publications both in national and international journals (37%), followed by the states of Rio de Janeiro and Minas Gerais. Also, Guimarães and Humann[26] reported that the implementation of Stricto Sensu graduate programs was one of the factors that stimulated scientific production in Brazil, and remarked the Southeast as one of the regions with the highest number of programs with an impact on scientific and technological development.

As possible hypotheses for researches on diagnostic tests for SARS-CoV-2 not having been started, the following are cited: the cut in the budget of federal universities in Brazil in the year 2021, the reduction of resources destined to the Ministry of Science and Technology and Innovations in the same year[27] and the withdrawal of incentive grants for researchers[28]. These cuts in research resources had been taking place since 2015, when a large part of transfers to research funding and research grants for researchers was interrupted in almost all state and federal research support agencies[29].

Survey carried out by the Institute for Applied Economic Research (Ipea)[30] on estimates of expenditure on RD&I for entities in charge of the the National Science, Technology and Innovation Policy, such as the Coordination for the Improvement of Higher Education Personnel (Capes), the National Council for Scientific Development and Technological Development (CNPq), and the National Fund for Scientific and Technological Development (FNDCT), points out that the federal budget has shown a downward trend since 2015. In that year, BRL 13,027 million was allocated to RD&I, and this amount has dropped to to BRL 5,216 million, even in the face of the best scenario estimated for 2020. In this document, it was shown that the National Innovation Policy should guarantee greater international competitiveness, public intervention in market failures in private RD&I activities, and prioritization of public investments in this area[30].

Arbix[31], comparing expenditures on RD&I in relation to the GDP of several countries, showed that Brazil is practically stagnant at around 1%. In the period from 2000 to 2013, other countries doubled their investments, such as Korea (which jumped from 2% to 4% of the GDP) and China (which increased from 1% to 2% of the GDP). According to this author, the understanding that technology and innovation are a driving force for economic growth and development still lacks consolidation and is hampered by fluctuations in public investment, regulatory insecurity, high production costs and deficient infrastructure, which has led to historical backwardness and technological dependence.

This scenario has had serious consequences, such as researchers leaving to other countries, the lack of motivation for new scientific discoveries and the decrease in the presence of low-income researchers in universities[32]. In addition, the closing of universities in the initial months of the pandemic due to restrictions on face-to-face activities may have had a negative impact on research development[33].

In this scenario, a relevant aspect stimulated by the pandemic was the formation of collaborative networks between universities and research institutes in São Paulo, aiming at achieving greater agility in the development, production and delivery of diagnostic tests to the public health system, so as to reduce the waiting list for biological materials depending on diagnosis, thus enhancing the actions of epidemiological surveillance. This network started to be coordinated by the Butantan Institute and was meant to face the problems arising from the limited national production and the massive competition in the acquisition of inputs in the international market. It was evidenced that partnerships between universities, public health and private sectors can be successful and potentially agile and effective in the translation of products originated from research to public health policies[34].

Quintella et al.[35], in a study developed to map clinical tests for the diagnosis of COVID-19 in the world and their respective funding sources, found that most of the identified research was subsidized by hospitals and, secondly, by universities, followed by government sectors, Non-Government Organizations (NGOs) and the business sector.

These findings corroborate the need for investment in public universities, since, as reported by Moura and Camargo Júnior[32], although some studies have direct influence on the health-disease process of the population and are of social relevance, it is very likely that they are not supported by private agencies of promotion, having public funding as the basis of their existence, as in the case of those in the area of public health.

Reinforcing this, Waldman[36] reports that health research has large dimensions and needs intersectoral actions between universities, teaching and research institutions and agencies that promote technological development. The performance of public universities is paramount to epidemiological surveillance actions, since their integration with the scientific community for the development of research contributes to the knowledge of diseases and the production of evidence in a timely manner for the planning of strategies to face them[37].

On the other hand, De Negri[38] argues that grants to research projects at universities and research centers in Brazil are, to a large extent, more guided towards the support of the scientific community than to the development of essential technologies for the country, and that public RD&I resources could be used to develop solutions in health and urban security, for example, as disease and urban violence are among the problems afflicting Brazilian society.

In this investigation, there were studies in Phase T3, that is, already incorporated into health care[39], including the topic of artificial intelligence. The acceleration of research on this topic is due to the need to decrease professional/infected patient contact, which minimizes the risks of contamination of professionals, increases the agility of screening, subsidizes diagnostic hypotheses in a more timely manner, promotes the visualization of organs through examinations of images, and favors the prognosis of viral infections[40,41].

Among developments also worth mentioning are the creation of a prototype that uses UVC radiation to fight COVID-19[42], the standardization of two protocols for molecular tests with low-cost reagents as alternatives for the diagnosis of COVID-19[43] and the formulation of a direct workflow RT-LAMP (Reverse Transcription Loop-Mediated Isothermal Amplification) which proved to be an effective tool for salivary detection of the virus[44]. These findings support the argument of the importance of strengthening the political pact for Science, Technology and Innovation (ST&I) in the area of public health in order to guarantee comprehensive access to diagnostic tests, and of the essential role that policymakers are playing to integrate ST&I activities with planning and public health policies[34]. In addition, the scientific community's agile response capacity to COVID-19 stands out, with adaptations being made in university laboratories so as to formulate alternative means for the diagnosis of SARS-CoV-2, and the innovative production of equipment and protocols for tracking the disease[34].

The non-identification of stage T4 in the present study corroborates what was documented by Titler[18], when the author remarks this gap and its consequent negative implications for the health of the population. TR in health becomes relevant insofar as it stimulates the translation of scientific development into something applicable, safe and beneficial in a timely manner[45], not depending on the evaluation of its impacts on public health.

Ferraz, Pereira and Pereira[46], in a scoping review carried out to investigate the challenges of knowledge translation today, in addition to government omission and scarce incentives from health institutions, identified that such challenges are related to the lack of understanding between the scientific community and the agents involved in decision-making, and with researchers not being able to translate and implement new findings. In this sense, Treichel et al.[47], based on the Research Management Committee they recurred to in their experience in the implementation of technologies in mental health, suggest the adoption of this tool due to its potential to promote dialogicity between research and practice, with continuous and significant implementation of its outcomes by the authors involved.

Another relevant aspect that can have an impact on the lack or slowness of knowledge translation is the lack of guidance of research towards results. Data showed that only 30% of public RD&I resources in Brazil are geared towards results, unlike the American case, where there is more than 90%[38]. Thus, there is a need for new public policies to guide innovation on this basis, with scalable infrastructure, clear objectives and coherent with the population's needs and with the purpose of overcoming the country's challenges and the improvement of society's life. Improving and professionalizing the institutional environments destined to RD&I could minimize solely academic nature of research conduction, not guided towards a concrete solution of problems[48].

As for the geographic distribution, a hypothesis for what was found in the Southeast region is related to strategies developed[49], such as the creation and maintenance of cooperation networks between universities that boosted the production of molecular diagnostic tests for the detection of the new coronavirus[50], especially in the city of São Paulo, where the translation proved successful through the use of products and technologies derived from research[34]. In addition, the establishment of partnerships for productive development that involve articulations between public laboratories and private pharmaceutical companies for the transfer of technology strengthens local production as well as acquisitions centralized by the Ministry of Health, making it possible to expand access and mitigate the vulnerabilities of Unified Health System (SUS), combining RD&I with the social economic dimension[51].

Although the amount of T3 research is mostly concentrated in the Southeast, for Garcia et al.[52], the lack of coordinated actions within the Brazilian federal government shifted the responsibility for adopting measures to mitigate the negative effects of the COVID-19 pandemic to states and municipalities. Thus, those who already had greater productive, technological and research capacity installed took the lead not only in adopting health measures, but also in RD&I, which ended up benefiting the entire national territory.

For Magno et al.[53], effective diagnostic measures are included among the best practices to prevent infection and control the transmission of SARS-CoV-2, and can complement syndromic surveillance by adding large-scale testing strategies. In the context of the COVID-19 pandemic, syndromic surveillance should be maintained as a routine, with sampling and laboratory tests of all or of a subset of cases, aiming to identify trends in other diseases that present themselves in a manner similar to that of SARS-CoV-2 and its symtomatology, to timely guide public health actions[54], being this a practice frequently used by public health surveillance systems focusing on the early identification of symptoms[55].

The correlation of research on diagnostic tests with the GDP was justified for this being is one of the main indicators of economic growth and because it is linked to the generation of wealth[56]. In this study, the GDP showed a linear association with the concentration of research in the Southeast, the region with the highest Brazilian GDP. A high GDP does not necessarily mean that the quality of life of the residents of a given location will be high, but it implies a high degree of flow of goods and services that, potentially, through adequate public policies, improve health indicators[57].

For Gadelha et al.[58], the disproportion between health expenditure and its distribution in Brazil is evident, this being something requiring not only a high increase in public funding in the health sector, but also the strengthening of the national productive base for economic adequacy under the perspective of universalization, considering the new configurations of demands, the evolution of technological processes, the competition (especially in the international market) and the regulatory aspects.

The HDI-M measures the quality of life in cities; therefore, knowing it and observing its relationship with other indicators, such as the mortality rate, helps to understand the dynamics of the spread of the new coronavirus and the need to develop research and technologies to promote the reduction in the amount of deaths and other damages caused by the pandemic in the territory[59]. Low HDI-M may be related to a higher incidence of Covid-19[60]. In a study that analyzed the spatial distribution of Covid-19 in the state of Pará in relation to the HDI-M, it was found that cities with a low HDI-M had a strong correlation with the rate of mortality from the disease, whereas those with a medium and high HDI-M were more strongly correlated with higher case recovery rates[61].

Since the data has a time limitation as it represents a sample of RD&I projects collected up to May 15 2020, and given that those are secondary data, they may be subject to subnotification. In addition, the classification of project themes was subjectively based on their description and to the objectives contained in the information found in the databases in which the surveys were consulted.

Final remarks

This study helped to broaden the view on diagnostic tests research for the detection of SARS-CoV-2 in Brazil, considering their implication with syndromic surveillance, identifying the TR stages of projects in this area, and their correlation with other indicators.

Even with the deep budgetary restrictions in RD&I, 15 innovations that reached the T3 stage were identified, with their products being incorporated in clinical protocols in health. Most of the surveys were at T0, and none at T4.

Although world-renowned universities and public research centers are located in Brazil, it is still necessary to promote their development, improving their infrastructure and encouraging the creativity of researchers towards a results-oriented science of excellence, with timely translation movements with products and technologies to be aimed at solving problems in Brazilian society.

There was a greater concentration of research in the Southeast, the region with the largest number of teaching institutions, research centers, researchers, PhD researchers and universities ranked among the 10 best in the country. The surveys were more present in locations with higher GDP, and this can be an indicator of local and regional inequalities.

Brazil has the potential to develop and implement technological products in the area of diagnostic tests for SARS-CoV-2. Public health RD&I policies need to be prioritized with a view to expanding national and international partnerships and cooperation, this including the industrial complex, in order to enhance and deconcentrate scientific-technological production, and to facilitate the implementation and evaluation of impact of its products, rescuing the primary function of health research, which is that of promoting the health of the population.

Collaborators

Cavalcante FV (0000-0002-8706-0457)* and Sacco RCCS (0000-0001-6131-0852)* contributed to the conception, design and planning of the study, analysis and interpretation of data, preliminary writing of the article, critical review and final approval of the content. Oliveira A (0000-0002-3084-6491)* and Araujo SQ (0000-0002-5152-6892)* contributed to the preliminary writing of the article, analysis and interpretation of data and final approval of the content. Pacheco C (0000-0003-1829-1515)* contributed to critical review and final approval of the content. ■

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*Orcid (Open Researcher and Contributor ID).

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